# Network Security

## DNS (In)security

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- SSH, SSHuttle, and corkscrew are helpful tools to circumvent firewalls

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- Meaning: Accept a redirect only to a known gateway
- Disables the idea of "dumb" clients that learn best routes from default gateway

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- DNS servers are typically resposible for one specific domain (DNS zone)

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- Recursive request (to a DNS cache): give me the answer or an error
- Iterative request (to an authoritative server): give me the answer or tell me who might know

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- 131.174.117.20 tells your client (e.g., SSH client) the IP address of `sandor.cs.ru.nl`

# DNS entry types

| Type | Meaning |
|---|---|
| A | Address record: returns a 32-bit IP address, used to map hostnames to addresses |
| NS | Nameserver: Lists the authoritative nameservers of a DNS zone |
| CNAME | Canonical Name: Assigns a hostname alias to a hostname |
| SOA | "Start Of Authority": Lists authoritative information about the zone: primary DNS server, mail address of administrator (with @ replaced by a .), serial number, refresh times and timeouts. |
| MX | Mail Exchanger: Gives a mail server responsible for the domain |
| TXT | Text field: Originally arbitrary human-readable text, today often used for machine-readable data |

# DNS entry types

- Four sections in a DNS reply:
  - The QUESTION SECTION (repetition of the question)
  - The ANSWER SECTION
  - The AUTHORITY SECTION
  - The ADDITIONAL SECTION
- ADDITIONAL SECTION is particularly important for *glue records*: communicate IP addresses of authoritative DNS servers

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    ```

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    dig -x 131.174.142.4
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- Find out about ICANN registration information of a domain: `whois`, e.g.:

  ```
  whois cryptojedi.org
  ```

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- DNS root servers are extremely critical piece of Internet infrastructure
- How many are there? Answer: 13
- Names of these servers: `a.root-servers.net` ... `m.root-servers.net`
- Those servers are actually highly redundant, some even distributed over the globe

# The DNS root servers

## DNS root servers hit by largest DDoS ever

News By Oct. 23, 2002 12:38 pm

The largest Distributed Denial of Service (DDoS) attack in history went largely unnoticed by the general public on October 21, 2002, but it was almost a disaster, say several Internet backbone operators.

Around 5:00 P.M. Eastern time, the root servers that handle domain name resolution for all top-level domains on the Internet were subjected to an hour-long attack by thousands of "zombie" computers-PCs that have been co-opted by a hacker into participating in an attack without the knowledge of the PC owner. Of the 13 root servers in existence, only four were able to keep operating during the attack. Had the attack continued for much longer, experts say, the remaining servers may have been overwhelmed, effectively strangling the entire root Domain Name Server (DNS) system. Although many ISPs and companies maintain



http://www.geek.com/news/dns-root-servers-hit-by-largest-ddos-ever-550549/

# The DNS root servers

Topic: Security

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## DNS root server attack launched from Germany

**Summary:** *According to a published report, the recent attack against the DNS root servers was launched from a host server in Germany that controlled millions of zombie machines in South Korea*

By Ryan Naraine for Zero Day | February 22, 2007 -- 09:41 GMT

Follow @ryanaraine  Get the ZDNet Security newsletter now

The distributed denial-of-service attack against the DNS root servers earlier this month was launched from a host server in Germany that controlled millions of zombie machines in South Korea, according to a report in The Korea Times.

Details of the cross-continent attack, which almost took out three of the 13 official root DNS servers are beginning to surface with South Korea's ministry of information and communication confirming that a host server in Coburg, Germany ordered hijacked Windows machines in Korea to stage the attacks.

http://www.zdnet.com/blog/security/dns-root-server-attack-launched-from-germany/50

# The DNS root servers


http://www.pcmag.com/article2/0,2817,2402469,00.asp

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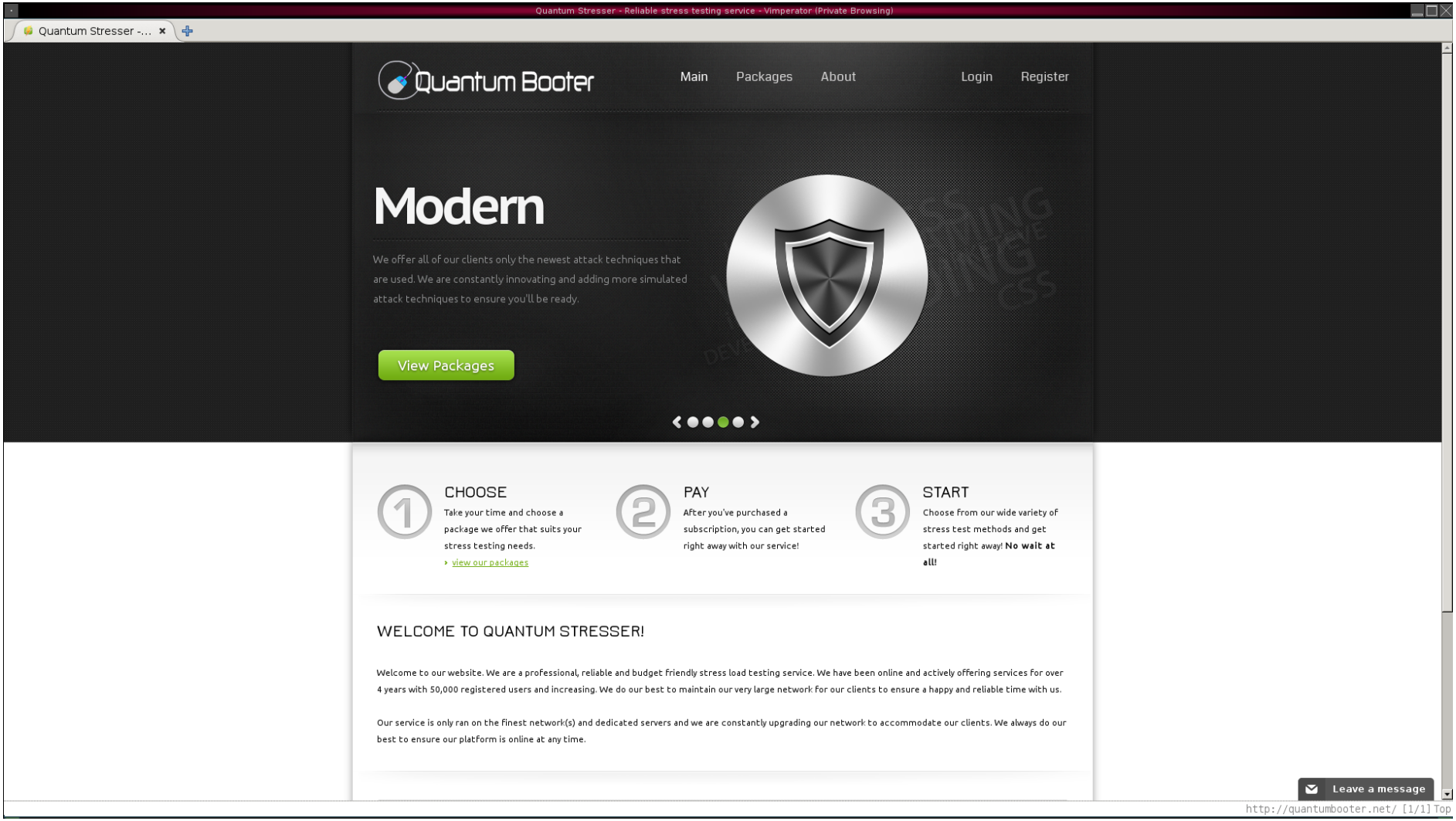
- This is slow (small payload, UDP is not reliable)
- Ready-made client/server: `ozymandns` by Kaminsky: http://dankaminsky.com/2004/07/29/51/
- Tutorial for DNS tunneling (with `ozymandns`): http://dnstunnel.de/

# DNS DDoS amplification

- DNS (typically) uses UDP
- No session establishment: send request, get answer
- Answer can be much larger than the request
- Idea: Spoof IP address of DOS victim in DNS request
- Victim will receive much more data than attacker has to send
- This is called *DNS (D)DOS amplification*

# DNS DDoS amplification



# DNS DDoS countermeasures?

- Very hard to defend against DDOS (and DNS amplification)
- Can (temporarily) block packets from open DNS servers
- Can (temporarily) block large DNS reply packets
- Can try to filter spoofed IP addresses (“ingres and egress filtering”)

# DNS spoofing

- Probably most obvious DNS attack: send wrong answer
- Send wrong answer to client: hit one target
- Send wrong answer to DNS cache: hit many targets
- Answers contain "validity period"
- It's possible to poison DNS caches for a pretty long time

# In the old days

```
$ dig @ns1.attacker.com www.attacker.com
    ;; ANSWER SECTION:
    www.attacker.com.     120       IN     A     123.45.67.8

    ;; AUTHORITY SECTION:
    attacker.com.         86400     IN     NS    ns1.attacker.com.

    ;; ADDITIONAL SECTION:
    ns1.attacker.com.     604800    IN     A     123.45.67.89
    www.target.com.        43200    IN     A      66.66.66.66
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## The bailiwick check

- Idea of the attack: wrong entry for `www.target.com` ends up in cache
- Countermeasure (since 1997): use *bailiwick* check
- Reject ADDITIONAL information if the requested server is not authorized to answer for the domain

# Short interlude: A bailiwick

## Definition of BAILIWICK

1. the office or jurisdiction of a bailiff
2. a special domain

Source: http://www.merriam-webster.com/dictionary/bailiwick

# Short interlude: A bailiwick

## Definition of BAILIFF

1. **a:** an official employed by a British sheriff to serve writs and make arrests and executions
   **b:** a minor officer of some United States courts usually serving as a messenger or usher
2. chiefly British: one who manages an estate or farm

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  - Include picture from `www.target.com`
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- Attacker can send *many packets*
- Attacker can also try to run DOS against real DNS server

# Kaminsky's attack (2008)

- Idea: Use website with many links on *subdomains*:

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<img src="http://aaab.target.com/image.jpg"/>
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    ;; AUTHORITY SECTION:
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    www.target.com.     604800 IN    A    66.66.66.66
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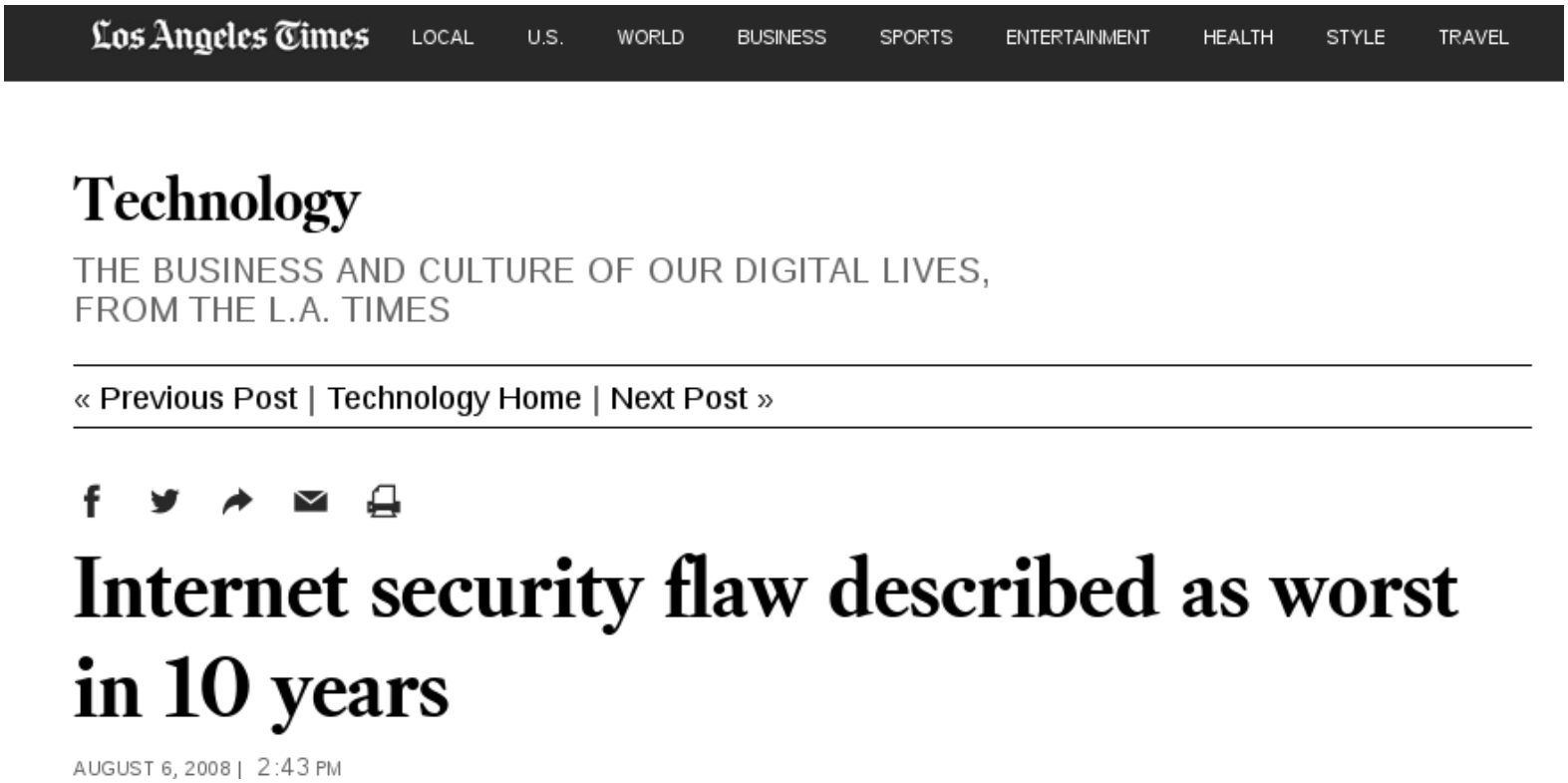
- The client requested the IP address with `target.com` domain
- The answer for `www.target.com` *passes the bailiwick* check!
- The value 604800 defines the validity period of the information: 7 days

# Impact of Kaminsky's attack


**1. "The Kaminsky Bug" puts the whole Internet at risk**

Often regarded as possibly the greatest security threat the Internet has ever faced, the so-called "Kaminsky Bug" emerged in July 2008, creating great unease and even greater hype. Researcher Dan Kaminsky discovered that it was easy to exploit a weakness in the DNS and built the software to do it. This weakness would enable malicious hackers to transparently imitate any Web page or e-mail account by poisoning the DNS information cached by Internet service providers.

# Impact of Kaminsky's attack



Los Angeles Times LOCAL U.S. WORLD BUSINESS SPORTS ENTERTAINMENT HEALTH STYLE TRAVEL

**Technology**

THE BUSINESS AND CULTURE OF OUR DIGITAL LIVES, FROM THE L.A. TIMES

« Previous Post | Technology Home | Next Post »

**Internet security flaw described as worst in 10 years**

AUGUST 6, 2008 | 2:43 PM

# Impact of Kaminsky's attack


http://www.nytimes.com/2008/07/30/technology/30flaw.html?pagewanted=all

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- Today, all DNS servers randomize the source port
- Potential problem with NAT: source port is rewritten

# Birthday attacks

- Imagine that a DNS server is sending out many *identical requests* (with different source port and QID)
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- Imagine that a DNS server is sending out many *identical requests* (with different source port and QID)
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- Any collision with one of the requests wins
- Do servers send out identical requests?
- Some do, e.g., `djbdns`'s `dnscache` (Kevin Day, 2009):
  - Trigger 200 identical queries (default size of query queue)
  - Need to be fast, send these queries before first reply is received
  - Increase attacker's success probability from $1/2^{32}$ to $200/2^{32}$

# More randomization?

- The QUESTION section of a DNS request is copied to the reply
- Some bits in the QUESTION section, don't matter:
  `www.ExAMPle.com` is the same as `www.example.com`
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- Slight problem: DNS standard does not *require* the QUESTION section to be copied bit-by-bit
- Other idea: query repetition (another $32$ bits of entropy)
- Adds additional complications (not broadly implemented)
- Bernstein on randomization:

  "It is clear that enough randomization effort would be able to stop all blind forgeries."

# The easy way...

- A passive MitM can read DNS requests
- Becoming a passive MitM is not that hard:
  - Sniff WiFi
  - ARP spoofing
  - Be an ISP
  - Be a network administrator in a company
- A DNS attacker can poison a DNS cache
- Affects many more clients than a MitM between clients!

# DNS censorship

- DNS can be used for censorship:
  - April 1997: German provider DFN blocks IPs of xs4all.nl
  - German "Zugangser-schwerungsgesetz"
  - "Child Sexual Abuse Anti Distribution Filter" (CSAADF) by CIRCAMP used in Denmark, Finland, Italy, Newzealand, Norway, Sweden und der Switzerland
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  - Circumvention: Use alternative DNS


Source: http://xkcd.com/1361/

# DNSSEC

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- Root of trust: public keys of the DNS root servers
- Additional (cryptographic) information in new DNS entry types:
  - RRSIG: DNSSEC signature
  - DNSKEY: public key to verify signature

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- DNSSEC does not increase the size of DNS requests
- DNSSEC does significantly increase the size of DNS replies
- Modern DDOS uses DNS+DNSSEC

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- DNSSEC does significantly increase the size of DNS replies
- Modern DDOS uses DNS+DNSSEC
- RFC 4033: "DNSSEC provides no protection against denial of service attacks. Security-aware resolvers and security-aware name servers are vulnerable to an additional class of denial of service attacks based on cryptographic operations."

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- RFC 4033: "DNSSEC introduces the ability for a hostile party to enumerate all the names in a zone by following the NSEC chain."

# NSEC3

- Idea: Hash domain names, sign information on gaps between existing *hashes*
- Example:
  - request for (non-existing) `test.example.com`
  - Hash `test.example.com` (with SHA-1), obtain: `401f83bc96721eeeba6f5c1c54cf0a83dc08a30b`
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- Software by Niederhagen: Try 6000 billion hashes per week on NVIDIA GTX295 GPU
- This is *much* faster than trying domain names through DNS queries

# More DNSSEC problems

- Second implication of offline-signed records: *replay attacks*
- Attack scenario:
  - Company runs server `www.example.com` at 123.45.67.89
  - DNS server sends signed name resolution for this name/IP, attacker records it
  - Company moves or changes provider, now `www.example.com` is at 98.76.54.32
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- DNSSEC uses bleeding-edge crypto (1024-bit RSA)
- DNSSEC does not encrypt queries; from RFC 4033:
  "Due to a deliberate design choice, DNSSEC does not provide confidentiality"

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- Potential disadvantage of DNSCurve: crypto keys need to be on DNS servers
- Addional disadvantage: It's much easier to deploy than DNSSEC, does not create as many jobs for consultants

# More reading...

- Dan Bernstein about DNSCurve (and DNSSEC vulnerabilities):
  - http://dnscurve.org/
  - http://cr.yp.to/talks/2010.12.28/slides.pdf
- Dan Kaminsky's answer:
  http://dankaminsky.com/2011/01/05/djb-ccc/

  "DNSSEC Is Not Necessarily An Offline Signer – In Fact, It Works Better Online!"

# Next lecture: October 14, 10:30, in HG00.307